Learning about Learning a Course on Neurobiology of Learning and Memory
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Lecture – 06
Application of Rescorla Wagner Model – I

Hello, and welcome to the lecture – 6, of the Learning about Learning. We have discussing about the mathematical model for describing the associative strength as a function of number of trials with which we are training in animal, alright.

So, in the last class we were plotting out the equation that came out from Rescorla and the Wagner's assumptions in the model.

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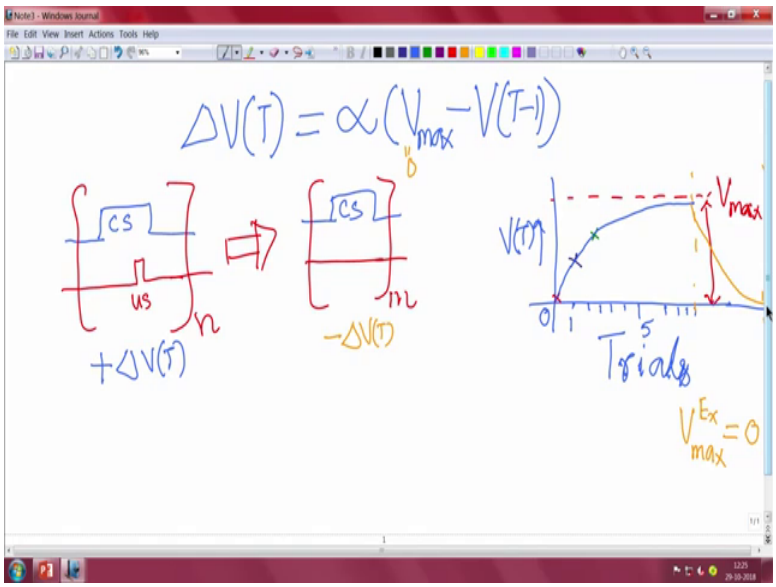

We wrote it as delta V the amount of learning incurred or the change in the response that you see in a trial T is given by a proportionality constant, we call it as an associative constant alpha times V max minus the response at the start of the trial, right, let us call it as V T minus 1, sometimes I do write it in the subscript. So, make sure that I mean consistent for to be concise I do write it in the subscript, ok, good.

And, we plotted out and this and then said, hey, look if you were to measure the animals response as a function of trials, right. So, the number of trials number you can think of that as the number of exposures the animal gets to the CS and the US combination, right. If you think of measuring the response V as a function of the number of trials and plot

out I said, let us take different colors for different exposures, initially we start with 0 response at the zeroth trial and first exposure or the first trial 5 and so on.

If you see given a CS and US combination there is a fixed V max we fixed it and since that is fixed we say hey, look even though animals started out at this point later on or when it comes back this whole element acts like a surprise, but not the entire surprise goes into the learning, but the fraction of that determined by the multiplier alpha because alpha is a number that is between 0 and 1, a fraction. So, if it were to be half then you would expect that to be somewhere the response to be somewhere here and it progressively increases though the amount of increase itself decreases, giving rise to this nice asymptotic curve, asymptotic nature.

The first thing that we will notice is that since the learning here or the alteration of the response that we are seeing is proportional to V max minus V t is that are there instances where you can conceive of where the learning bit itself becomes negative, right because for some reason if you have a response that is greater than V max when I said that you may feel like well what is he doing him contradicting my own statement, right because you said the V max is the maximum response now suddenly you are saying that for how can it be a V T a response that is greater than V max.

Remember V max is the maximum response for a given U S, right. So, if the US is an electric shock and the response the animal develops for a association with any CS could be a stereotypic response which you call it as freezing or some other response like avoidance response that we have seen already in the course.

Now, there is no limit for how much of a response that the animal can do, right; I mean there is a physiological limit I mean animal can mean if you are measuring freezing the animal can completely remain standstill all throughout the time that we cannot exceed. But assuming that we have not reached that point, and the V max is not anywhere closer to that you see that the response the animal can attain has no fixed number.

It is only the response that then, what is this V max is about? The V max is the response that the animal will attain for very number infinite number of the CS – US presentations no matter how many number of times you keep presenting the CS and U S, it is going to be just there, ok. Let us think of this with one little example. Let us say we are going to

measure this avoidance response, for an electric shock which is say given by say 0.2 milli amperes, ok. So, mild shock, so, the animal needs to develop a response.

See, all of these responses are of ecological significance. If this not useful for the animal sorrel it better not learn it, right. That is the whole philosophy of this entire course, right. So, if it is of any significance of that kind then there is no use to develop a response that is super high for a magnitude that a for stimuli that is only miniscule in its intensity. So, there has to be a proportional response, right and given stimuli should be able to develop a response in a proportional manner, right. So, the V max is like that for a 0.2 milliampere shock you would have a response that will be a V max corresponding to 0.2 milliampere shock. However, if you change the intensity of the shock V max changes.

Now, clearly you can now conceive of a situation where the response right the response that we are measuring, right, the avoidance response. It could be because of a different electrical shock that when you are measuring that you are not presenting in electric shock you are just measuring playing the CS and then measuring the response, right that could be elicited by a different US for altogether.

Or for all that matter one can do a kind of an experiment known as an extinction experiment that is you have paired consistently so far and electric shock with let us say a tone. So, the animal has developed a response for it let us measure the measure that through an avoidance task. So, we have an avoidance response measure. Now, you stop pairing the tone with the electric shock. Clearly things have changed now. If the learning were to be of any significance for its survival of any significance ethologically and evolutionarily then the animal should be able to modify its response because there is no point responding in the same way to a stimuli which has not having this contingency any longer. There is a way to change it and that is given by extinction.

Now, this US which is practically there is no US has 0 maximum the V max is 0. So, what you are doing is initially we were talking about pairing CS along with uS in a contingent manner we do it we do repeat this n number of times again and again and again and again. After this what we do now is we are just going to present CS, but no US. Now, clearly the animal need to understand some m number of times, the animal need to understand. Hey, maybe something wrong was happening before I should not have to respond this, right in a in this manner.

So, now, that is an extinction which is we do see that the animal starts to not start to inhibits its expression of new response and if you measure that as a function of these m trials, you will see that this response indicated by a saffron progressively goes down to now that is very nicely captured by this one expression. How does it capture it? For this part of the trial the V max that we are looking at is actually the V max during extinction is actually 0.

So, if we do that in this expression, if you substitute that in this expression, you can see the delta V that you are going to get since it is going to be 0 the delta V that you are going to get will be negative, right. So, you will have negative delta V's during extinction while in this case in the case where you are contingently pairing the CS with the US all throughout you will have a positive delta V. Because it is negative you can see progressively it goes down, it is just exactly opposite reverse of what we have learned.

The nice part is we do not have to do anything, the extinction comes out from this expression vary naturally if you meaningfully plug in what V max and alpha are. That is one rather two direct illustration of how we go about using this model in understanding the development of the response as a function of trials. I told you that this any model that we develop should be able to capture three important things contingency, different strengths of the CS – US association dictated by the nature of the CS and the US and inhibition due to pre learning. Let us revisit that.

Let us start with the last, the inhibition due to pre learning that is Kamin's blocking experiment. How do we go about explaining that using this model? We do not have to do anything if you understand if you understand the model and how this expression comes we just go ahead we are going to just go ahead and write down what these responses are going to be. Even at a phenomenological level you can see that it beautifully tells you why Kamin would have observed what he observed, without you or we having to put anything extra into this model.

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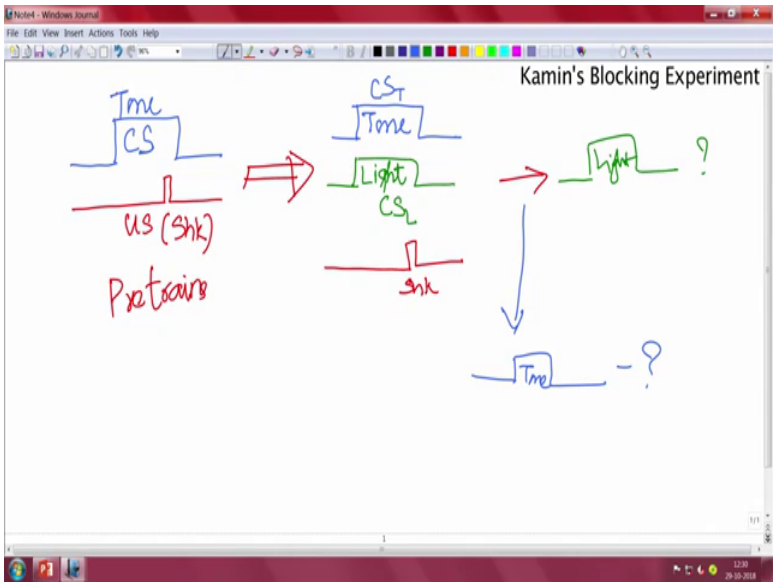

So, let us revisit his experiment. The experiment is there are two groups of animals. Let us look at the main group. He pre-trains these animals in CS and the us here the CS being tone and you can think of the US as shock abbreviated as shk. So, this is a pre training regime. Once he pre trains then he takes them into a compound stimuli regime where he is presenting two different CS's tone let us call it as CS 1 or CS T and light a flash of light; CS subscript L.

He presents this along with a US just like before an electric shock and asks if I were to just play or just show the light what is my learning. If I were to just present the tone, well so, he is not presenting two together. So, let me not give you that impression or if I were to just present the tone what is my response, have a developed a new response alright.

So, clearly we are going to get into the idea of compound stimuli presentation. So, let us rewrite the expression that we have been using for the individual or a single CS US association in terms of the compound stimuli presentation, alright. So, there are a few ways to do about go about doing that one of the convenient way which I like most is writing out the change in response for the individual stimuli themselves.

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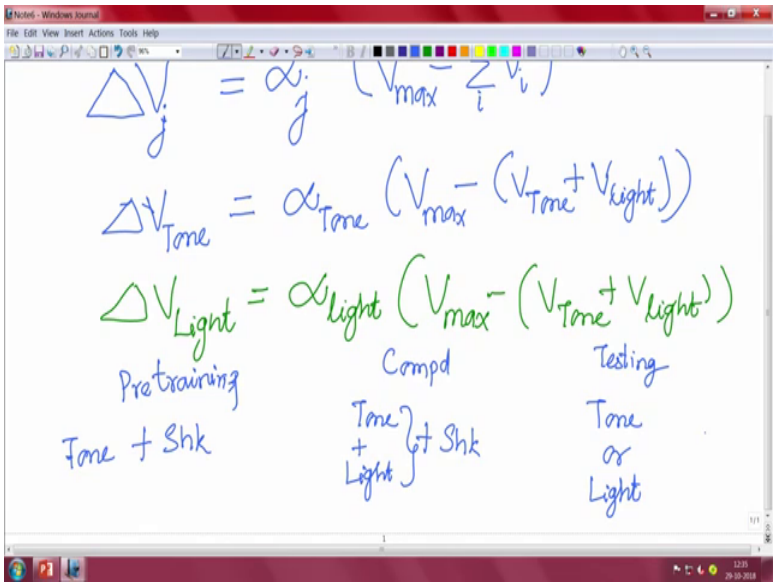

And, you can get that by understanding that the change in response in tone is given by the associate ability of the tone times V max minus. So, until here there is no big difference it is here that is a very very important and vital difference what the model says is the surprise is not just the difference between the V max and the tone response, but it is actually V max and the sum of all the stimuli that can elicit the response. The response because the animal is responding for both the tone and the light. So, you have to add them both.

So, you can think of the way you want to write that in a general way here is i and V i for completions mean for a consistency sake if you are thinking in terms of generalizing this expression for across multiple stimuli I would replace that with some j and this i includes j, right. You add up all the stimuli, good. So, you can write down like that you can write down for tone, you can write down for the light. So, in our specific case then we will write it as delta V tone is equals alpha tone times V max minus in since we have only two we will add both of them V tone plus V light.

And, similarly delta V the change in response for the light would be given by alpha of the light times V max this is exactly equal. So, just that I am changing the color, but that is the V max here is equal because it is governed by the US and not by the CS's, right, V tone plus V light; which would mean in our case during the pre-training he is the animal is actually developing a response to the tone, right.

If you remember if we can go back to our the design or maybe I will just draw the design all over again where you can see that his experimental design involved two phases a pre-training phase Kamin's experiment involved a pre-training phase and compound stimuli phase and the testing phase ok. The two phases that I was talking about is the trainings in the training, pre-training and compound apart from that he is using also the testing.

During the pre training what is he doing? He is giving tone plus shock in the compound he is doing tone along light both of them are paired with shock and during the testing he either presents a tone or the light and asks how much is the learning or how much what is the response.

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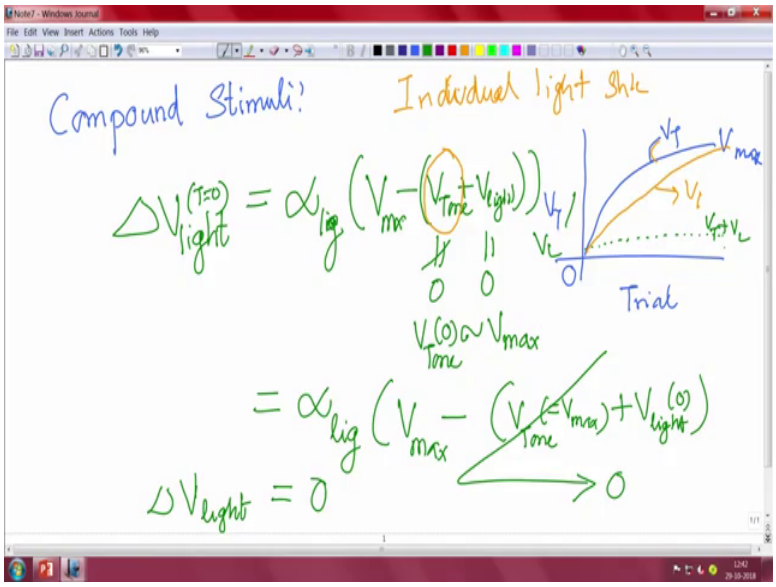

So, if you look at this then what we will see is that when we write down during the compound stimuli the I am going to look at the response graph responses as a trial graph during the compound stimuli, ok. Let us start from trial 0 of the compound stimuli. What the response would be since we have pre trained the animal in the tone, so, our response would be whatever the response the animal has acquired for the tone at the very end of the pre training.

So, if I were to actually ask the learning incurred during this compound tile compound trial for the light then that would be alpha light times V max minus V tone plus V light at the start of the trial. Now, granted this is equal to 0 because it is the start of the trial right at this is the trial number T equal to 0, ok. So, however, this is not equal to 0 it is

nonzero. In fact, if you do the pre training well this would be almost equivalent to so, almost is so, the V tone at the start of the trial is almost equivalent to V max because V is the shock US is common between the tone and the light and the pre training.

So, the V max here is determined by the US strength and he is not changing that. So, if you really pre-trained well he V tone would be close to V max as a result what we have is as for light the learning in the first trial because of this compound stimuli pairing for the light shock association would be V max minus V tone which is equal to V max, right. So, let me write it more explicitly V tone within bracket V max due to the prior learning plus V light which is actually 0.

Since this V tone equal to V max even though this whole term becomes equal to 0 because this sum is exactly equivalent to the V max. As a result if you ask V light has it has it has the animal changed its response? No, it does not. It did not and what you see is that even though if you are measuring the tone response indicated by the blue assuming that it has reached the V max you have a beautiful response here. However, if you add to measure V light, slash V light you will see that no matter how many our trials you give it into in the form of the compound stimuli it is exactly going to remain like this.

However, that is not to say if we were to separately couple the V light or the pair the light with the shock, right not in the form of tone plus light and then shock, but instead in the form of light and the shock. Then in such a case there is no compound stimuli. So, this tone term does not come in because it is only light, right. So, in such a case it learns just like regular learning.

So, I am stating it again in an individual or a individual light shock pairing you would see me granted the I mean the granted the alpha could be different, but the V max is same, they might reach this beautiful learning curve. However, the key here is when they are present with this the orange would be the V light and this is the blue here is the V tone and the dotted green is the compound V tone plus V light. And, this is exactly what we see what Kamin saw.

The point is that because they are compounds presented in a compound stimuli the animal is already responding for the tone. There is no purpose or there is served by the light being acting as a CS. It does not give any more contingency than the tone. So the animal does not form a response it is very tempting to say it ignores the light in whether

it does or not is altogether a different debate. However, it is safe to say that V L does not, the second are the supply any other stimuli for that matter will not are any number of stimuli also for that matter will not form a response will not develop a response when one of them is majorly dominant, one of them have already a dominant response, ok.

So, that covers the Kamin's portion of it. In the next lecture we will see how this explains Garcia Collings observation and the contingency. It is not very trivial, very straightforward, how the contingency is captured in this model alright, but we will see that and we will understand a very key concept about background conditioning and what is a background in doing so and then directly it well known or it will jump to what kind of predictions Rescorla Wagner model can make and how we can go ahead test and test it. With that we end the lecture 6 of this lecture series; I hope to see you on the lecture 7.